IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Burnham et al. Docket No.: BUR920020109US1

Serial No.: 10/604,905 Art Unit: 2813

Filed: August 26, 2003 Examiner: David S. Blum

Title: **METHOD FOR FABRICATING A NITRIDED SILICON-OXIDE GATE DIELECTRIC**

Honorable Commissioner for Patents
P. O. Box 1450
Alexandria, VA 22313-1450

BRIEF OF APPELLANT

This Appeal Brief, pursuant to the Notice of Appeal filed June 28, 2006, is an appeal from the rejection of the Examiner in the Office Action dated March 28, 2006.

REAL PARTY IN INTEREST

International Business Machines, Inc. is the real party in interest.

RELATED APPEALS AND INTERFERENCES

None.

STATUS OF CLAIMS

Claims 1,4, 6-15 and 31-38 are rejected. Claims 2, 3 and 5 are canceled. Claims 16- 30 are withdrawn. The rejection of claims 1,4, 6-15 and 31-38 are being appealed.

STATUS OF AMENDMENTS

In an interview with Examiner David S. Blum on August 17, 2006, the Examiner indicated that the After-Final Amendment filed on May 24, 2006 was not entered.

SUMMARY OF CLAIMED SUBJECT MATTER

A. CLAIM 1 - INDEPENDENT

A method of fabricating a gate dielectric layer (110A). The method comprises: forming a silicon dioxide layer (110) on a top surface of a substrate (100/195); placing the substrate (100/195) in a first chamber (185) having a inlet first port (210A) and a second inlet port (210B); generating a plasma (205) in a second chamber, the plasma (205) comprising at least one nitridation species, the second chamber (210A) adjacent to the first chamber (185), the second chamber connected to the first chamber (185) by the inlet first port (210A) in the first chamber (185); transferring the nitridation species of the plasma (205) from the second chamber to the first chamber (185) through the first inlet port; and performing a plasma nitridation in the first chamber (185) using the nitridation species in a reducing atmosphere to convert the silicon dioxide layer (110) into a silicon oxynitride layer (110A). See FIGs. 1-3 and paragraphs 17-19, FIG. 6 (steps 150 - 170) and paragraphs 22-27, FIG. 7 and paragraphs 31-33, and FIG. 10 and paragraph 40.

B. CLAIM 6 - INDEPENDENT

A method of fabricating a gate dielectric layer (110A). The method comprises: providing a substrate (100/195); forming a silicon dioxide layer (110) on a top surface of the substrate

(100/195); performing a plasma nitridation in a reducing atmosphere to convert the silicon dioxide layer (110) into a silicon oxynitride layer (110A); wherein the step (160) of performing a plasma nitridation is performed using plasma (205) comprising nitrogen, an inert gas and a reducing gas; and wherein the inert gas is helium and the reducing gas is hydrogen. See FIGs. 1-3 and paragraphs 17-19, FIG. 6 (steps 150 - 170) and paragraphs 22-27, FIG. 7 and paragraphs 31-33, and FIG. 10 and paragraph 40.

GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

1. Claims 1, 7-15 and 31-33 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Kobayashi (EP 0 886 308 A2) in view of Senzaki (US 2006005106A1).

2. Claim 34 stands rejected under 35 U.S.C. §103(b) as being unpatentable over Kobayashi (EP 0 886 308 A2) in view of Senzaki (US 2006005106A1) and in further view of Park (US006962873B1).

3. Claims 35-38 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Kobayashi (EP 0 886 308 A2) in view of Senzaki (US 2006005106A1) and in further view of McFadden (US 6610615B1).

4. Claim 6 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Kobayashi (EP 0 886 308 A2) in view of McFadden (US 6610615B1).

ARGUMENT

GROUND OF REJECTION 1

Claims 1, 7-15 and 31-33 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Kobayashi (EP 0 886 308 A2) in view of Senzaki (US 2006005106A1).

As to claim 1, the Examiner has stated " Kobayashi teaches forming a silicon dioxide layer on a top surface of a substrate (column 2, lines 55) performing a plasma nitridation in a reducing atmosphere to convert the silicon dioxide into a silicon oxynitride layer (column 3 lines 13-28, reaction gases listed include reducing atmosphere gasses). Kobayashi teaches nitridizing with a plasma, but does not teach where the plasma is made or how it is introduced (although its introduction into the chamber suggests a second chamber for making the plasma). Senzaki teaches forming a silicon oxide (high-k silicon oxide) on a substrate and introducing a nitrogen plasma into the chamber (thus two chambers) (abstract). The nitrogen plasma (thus at least one nitridation species is made in a separate chamber (paragraph 0022) and introduced via a gas delivery system (one inlet connecting two chambers) the chamber containing the substrate also has a system for purging, thus a second inlet (paragraph 0016)."

First, the Examiners statements concerning "where the plasma is made" is not correct. Appellants point out that Kobayashi clearly indicates in col. 11, lines 22-26 that the plasma is generated between grid electrode 105 and substrate 102 which are in the same chamber 101 as the silicon dioxide layer. The Examiners suggestion of a second chamber in Kobayashi is thus untenable. Appellants maintain there is no need to modify Kobyashi with Senzaki since Kobyashi is clear on where the plasma is generated and there is no motivation recited in the prior art for doing otherwise. Further, the Examiner has offered no evidence that the method of

Senzaki for nitridizing HfO_2 can be applied to SiO_2.

Second, Appellants point out that clearly there is no second inlet port to the process chamber taught in either Kobayashi or Senzaki. FIG. 10 of Kobayashi shows only a single input port to chamber 101 from a manifold. FIG 1 of Senzaki shows only a single inlet port to chamber 12 through an injector 16. FIG. 4 of Senzaki shows only a single inlet port to chamber 400 from source 403. Further, paragraph [0016] of Senzaki does not teach there is a second inlet port into chamber 400 for a purge gas. Paragraph [0016] only states "excess first reactant is evacuated from the reaction chamber with preferably with the aid of a purge gas" , a second reactant is then introduced to the reaction chamber" and "excess second reactant is evacuated, preferably with the aid of an inert purge gas." The Examiner has assumed the existence of a second inlet port with out any proof of its existence or has confused the concept of a manifold with that of a port in a chamber. All reactants and purge gas of Senzaki whether supplied from chamber 12 of FIG. 1 or chamber 400 of FIG. 4 enter through a same single inlet port in the wall of respective chambers 12 and 400. In fact, no inert gas connection is even indicated in Senzaki FIG. 1.

Third, Appellants maintain that replacing the filament plasma source of Kobayashi with the remote plasma source of Senzaki will destroy the function (not result in the same nitridation profile) of Kobayashi. Kobayashi teaches in FIG. 9, a nitridation profile where the nitrogen concentration increases with increasing distance from the surface of the silicon dioxide, while Senzaki teaches in FIGs 2 and 3 a nitridation profile where the nitrogen concentration decreases with increasing distance from the surface of the hafnium silicate. A person of ordinary skill in the art would know that the nitridation profile is a function of not only the type of plasma source but other variables such as the temperature of the layer to be nitrided, nitrogen species type and

concentration in the plasma, pressure of the plasma, power level of the plasma, plasma temperatures and nitrogen source gas and inert gas flow rates to name a few. For example, Kobayashi requires a plasma pressure of 0.015 torr (col. 6, line 32), while Senzaki requires a plasma pressure of about 5 torr (paragraph [0029] and Table I). A person of ordinary skill in the art would have to perform an undue amount of experimentation (and with no certainty of success) to determine what if any combination of variables would be required to replace the filament plasma source of Kobayashi with the remote plasma source of Senzaki and still obtain the nitridation profile of Kobayashi.

Fourth, Appellants maintain that the assembly taught by Senzaki was not commercially available, only parts. Appellants point out that in paragraph 22 of Senzaki it is stated that "One example of such plasma generator is ASTRON plasma generator available from MKS Instruments in Andover, Mass. One example of the reaction system is APNext Deposition system, available from Aviza Technology, Inc in Scotts Valley, Calif. Clearly, because of the two manufacturers involved, the assembly illustrated in FIG. 1 and 4 was not commercially available and it is impossible to determine, without undue experimentation, precisely where to locate and how to attach the generator chamber to the process chamber. Further, the Examiner has offered no proof that Kobayashi is not already using commercially available equipment.

Fifth, Appellants maintain that the rejection is improper because there is no suggestion in the prior art to combine the references as required by *Karsten Mfg. Corp. v. Cleveland Gulf Co.*, 242 F.3d 1376, 1385, 58 U.S.P,Q.2d 1286, 1293 (Fed. Cir. 2001) which states " In holding an invention obvious in view of a combination of references, there must be some suggestion, motivation, or teaching in the prior art that would have led a person of ordinary skill in the art to select the references and combine them in the way that would produce the claimed invention."

The alleged motivation "to modify Kobayashi by using the remote nitridizing system as described by Senzaki as it was commercially available at the time of the instant invention rather than spend research time and money developing original equipment" does originate from prior art but has been supplied by the Examiner. Therefore, the Examiner has not established his prima facie case of obviousness.

Sixth, *C.R. Bard, Inc.* v. M3 Sys., Inc, 157 F.3d 1340, 1352, 48 U.S.P.Q.2d 1225, 1232 (Fed. Cur. 1998) which state "no prior art provided a teaching, suggestion or motivation that a needle assembly should be made with the structure shown and claimed in the '056 patent", and stating that { a showing of a suggestion, teaching, or motivation to combine the prior art references is an 'essential evidentiary component of an obviousness holding'." Appellants cannot find and the Examiner has not provided any teaching, suggestion or incentive for combining Kobayashi with Senzaki in the prior art. Absent such showing in the prior art, Appellants contend that the Examiner has impermissibly used the Appellants' teaching to hunt through the prior art for the claimed elements and combine them as claimed in violation of *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed Cir. 1991) which states "the suggestion and reasonable expectation of success must be founded in the prior art, not in the Appellant's disclosure."; *In re Bond*, 910 F.2d 831, 15 USPQ2d 1566 (Fed Cir. 1990) and *In re Laskowski*, 871, 910 F.2d 115, 117, 10 USPQ2d 1397, 1398 (Fed. Cir. 1989).

Based on the preceding arguments, Appellants respectfully maintain that claim 1 is not unpatentable over Kobayashi in view of Senzaki and is in condition for allowance. Since claims 4, 7-15 and 31-38 depend from claim 1, Appellants respectfully maintain that claims 4, 7-15 and 31-38 are likewise in condition for allowance.

As to claim 4, Appellants note, that no explanation for the rejection of claim 4 was given in the Office action of March 28, 2006. Therefore, Appellants request that the rejection of claim 4 be reversed.

As to claim 9, the Examiner stated "Kobayashi does not teach a resultant oxynitride layer of about 8-24 angstroms, but does teach the goal of the invention to have a resultant gate insulating film of 3nm (30 angstroms) or less (column 1, lines 29-30), which is about 8-24 angstroms."

Appellants contend that claim 9 is not obvious in view of Kobayashi in view of Senzaki because Kobayashi in view of Senzaki does not teach or suggest every feature of claim 9. For example, Kobayashi in view of Senzaki does not teach or suggest "wherein said silicon oxynitride has a thickness of about 8 to 24 Å."

First, Appellants point out that "a resultant gate insulating film of 3nm (30 angstroms) or less(column 1, lines 29-30), which is about 8-24 angstroms" is not the goal of Kobayashi's invention as the Examiner alleges, but the description of the related art. Col. 1, lines 29-30 of Kobayashi appear under the heading of "Description of Related Art" and state "For example, under the design rule of 0.1 um or less, gate insulating films must be as thin as 3 nm or less." Kobayashi is (as the Examiner admits) silent as to the physical thickness of the resultant silicon oxynitride layer of Kobyashi.

Second, the Examiner stated "3nm (30 angstroms) or less.... is about 8-24 angstroms." Appellants note the difference between 24 Å and 30 Å is 25%. Appellants note the normal meaning of about as defined by the Oxford Dictionary is approximately, around, nearly. Appellants maintain a difference of 25% indicates 30 Å is not "about" 24 Å.

Third, Senzaki gives a Tox thickness of 17.4 Å for a HfON layer (paragraph 33) but this is a obviously an silicon oxide equivalent thickness not a physical thickness since (1) the starting film of HfO_2 was physically 50 Å thick (paragraph 26) and Table 2 (paragraph 33) list the Tox for this film as 31.8 Å (Run No. 1, as deposited), 31.5 Å (Run No. 3, as deposited) and 31.9 Å (Run 5, as deposited), (2) paragraph 33 indicates a mercury probe was used for the Tox measurement (thus an electrical, not physical measurement). Further one of ordinary skill in the art would expect (1) a nitridation process not to thin out the film be nitrided and (2) physically thick HfO_2 and HfON films act electrically as thinner silicon oxide films (that is the whole point of using high-K dielectrics of which HfO_2 and HfON are examples).

Based on the preceding arguments, Appellants respectfully maintain that claim 9 is not unpatentable over Kobayashi in view of Senzaki and is in condition for allowance.

Appellants contend that claim 13 is not obvious in view of Kobayashi in view of Senzaki because Kobayashi in view of Senzaki does not teach or suggest every feature of claim 13. For example, Kobayashi in view of Senzaki does not teach or suggest "wherein said silicon oxynitride layer has a thickness of about 0 to 35% greater than the thickness of said silicon dioxide layer." The Examiner states that "Kobayashi is silent as to the growth of the silicon oxynitride as to the silicon oxide layer, but teaches the resultant oxynitride layer cannot be made greater than a certain level (column 1 lines 56-57). Further, Kobayashi teaches the nitrogen to be incorporated into the silicon oxide film, but does not teach or suggest any thickness growth, only control of the resulting thickness. Thus without evidence to the contrary, Kobayashi suggests a growth of 0-35%."

Appellants respectfully point out that col. 1, lines 56-57 of Kobayashi state "According to

conventionally practiced thermal oxynitridation...the method involved the problem that the thickness of a formed oxynitride film can not be made greater than a certain level." First, this is simply a statement of a problem in the prior art and for a method different from that of Kobayashi and not a teaching about the method of Kobayashi. Thus, the only teaching in Kobayashi is that in the prior art, there was a increase in thickness, but the magnitude is not taught.

Based on the preceding arguments, Appellants respectfully maintain that claim 13 is not unpatentable over Kobayashi in view of Senzaki and is in condition for allowance.

As to claim 14, the Examiner states that "Kobayashi is silent as to the thickness of the resulting layer's mean thickness varying by no more than 0.5 angstrom sigma from a center to an edge of the substrate. However, Kobayashi teaches the method (which is identical to that of the instant claims) for improved control of the resultant film. Thus without evidence to the contrary, the method of Kobayashi will result in the mean thickness varying by no more than 0.5 angstrom sigma from a center to an edge of the substrate."

Appellants contend that claim 14 is not obvious in view of Kobayashi in view of Senzaki because Kobayashi in view of Senzaki does not teach or suggest every feature of claim 14. For example, Kobayashi does not teach or suggest "wherein the mean thickness of said silicon oxynitride layer varies by no more than about one-half angstrom sigma from a center to an edge of said substrate."

First Appellants disagree with the Examiners premise that "Kobayashi teaches the method (which is identical to that of the instant claims) for improved control of the resultant film." The method of Kobayashi is not "identical" with Appellants method. For example,

Kobayashi uses a tungsten filament to generate a plasma in a single chamber right over the substrate, while Appellants generate a plasma by RF excitation away from the chamber the substrate is in. Kobayashi heats the wafers with UV, Appellants use a thermal chuck. Any person of ordinary skill in the art would know that the apparatus of Kobayashi absolutely cannot perform the same method the Appellants process. Further, if the method was the same, the rejection should be a 35 USC 102 based rejection not a 35 USC 103 based rejection.

Second, Kobayashi does not teach "improved control" as the Examiner alleges. Kobayashi in section 57 states a goal of "capable of improving the quality and electrical properties of the insulating film." This is ambiguous since the quality is to be improved is not given and it cannot be assumed the quality is thickness uniformity.

Third, Appellants, in Table I, have provided uniformity data that is lacking in Kobayashi. A person of ordinary skill in the art would expect if, the method of Kobayashi could provide the uniformity in Appellants claim 14, Kobayashi would have provided data as Appellants have, particularly in light of the multiplicity of tables of data relating to process conditions that Kobayashi provides. Further Appellants FIG. 8 and accompanying text in paragraph 34 compares thickness uniformity of Appellants process (curve 230, sigma 0.97) to one without a separate reducing gas flow (curve 225, sigma 0.5) (Kobayashi does not have a separate reducing gas flow). Appellants take these to facts as providing evidence to the contrary.

Fourth, the Examiner admits Kobayashi does not teach the limitation of Appellants claim 14 and has argued prima facie obviousness without compelling evidence and in doing so has impermissibly shifted the burden of proof of prima facie obviousness to the Appellants.

Based on the preceding arguments, Appellants respectfully maintain that claim 14 is not unpatentable over Kobayashi in view of Senzaki and is in condition for allowance.

As to claim 15, the Examiner states that "Kobayashi is silent as to the nitrogen concentration not varying by more than 25% from a center to an edge of the substrate. However, Kobayashi teaches the method (which is identical to that of the instant claims) for improved control of the resultant film. Also, Kobayashi teaches a concentration gradient only with the depth of the thickness, suggesting a uniform concentration along the surface. Thus without evidence to the contrary, the method of Kobayashi will result in the mean thickness varying by no more than 0.5 angstrom sigma from a center to an edge of the substrate."

Appellants contend that claim 15 is not obvious in view of Kobayashi in view of Senzaki because Kobayashi in view of Senzaki does not teach or suggest every feature of claim 15. For example, Kobayashi in view of Senzaki does not teach or suggest "wherein the nitrogen concentration of said silicon oxynitride layer varies by not more than about 25% from a center to an edge of said substrate."

Appellants contend that a person of ordinary skill in the art would expect if, the method of Kobayashi could provide the uniformity in Appellants claim 15, Kobayashi would have provided data as Appellants have, particularly in light of the multiplicity of tables of data relating to process conditions that Kobayashi provides. Further Appellants FIG. 9 and accompanying text in paragraph 39 compares thickness uniformity of Appellants process (curve 245, 13-13,5 Å) to one without a separate reducing gas flow (curve 240, 25 to about 27.Å) (Kobayashi does not have a separate reducing gas flow). Appellants take these to facts as providing evidence to the contrary.

Based on the preceding arguments, Appellants respectfully maintain that claim 15 is not unpatentable over Kobayashi in view of Senzaki and is in condition for allowance.

As to claim 32, the Examiner states "Senzaki generates a nitrogen, inert gas and reducing gas in the second chamber and transfers it to the first chamber through a first inlet port (see FIGs. 1 and 4). Appellants are actually claiming "generating a nitrogen, inert gas and reducing gas plasma in said second chamber from nitrogen, an inert gas and a reducing gas; and transferring said nitrogen, inert gas and reducing gas plasma from said second chamber into said first chamber through said first inlet port of said first chamber."

First, Appellants point out the Examiners rejection is incorrect on three counts. (1) In FIGs. 1 and 4 of Senzaki, the second chamber generates various plasma species from various gases. The gases (i.e. nitrogen, inert gas and reducing gas) are not generated in the second chamber. (2) In Senzaki FIG. 1, only inert plasmas species (Ar+) and nitrogen plasma species (N) are generated by chamber 14. There is no reducing gas plasma species generated. (3) In Senzaki FIG. 4, plasma species are generated from N_2 and/or NH_3. There is no neutral reducing gas introduced into the chamber. Therefore the claim limitation "generating a nitrogen, inert gas and reducing gas plasma in said second chamber from nitrogen, an inert gas and a reducing gas" is not satisfied by Senzaki.

Second, the Examiner introduced Senzaki to modify the equipment limitations of Kobayashi and not in the positive steps of Kobayashi stating "Kobayashi teaches all the positive steps of claims 1, 7-15, and 31-33) except for the limitations regarding the equipment used." Therefore the rejection of claim 32 based on limitations to the positive steps (the gas mixtures) as taught by Senzaki is unnecessary (Kobayashi teaches suitable gas mixtures) as well as improper.

Based on the preceding arguments, Appellants respectfully maintain that claim 32 is not unpatentable over Kobayashi in view of Senzaki and is in condition for allowance.

As to claim 33, the Examiner stated "Senzaki teaches the inert gas is argon or helium"

Appellants claim 33 states "wherein said inert gas is helium and said reducing gas is deuterium, deuterated ammonia, a mixture of deuterium and nitrogen, a mixture of deuterated ammonia and nitrogen, a mixture of deuterium, deuterated ammonia and nitrogen, or a mixture of deuterium, ammonia and nitrogen."

Appellants maintain that the Examiner introduced Senzaki to modify the equipment limitations of Kobayashi and not in the positive steps of Kobayashi stating "Kobayashi teaches all the positive steps of claims 1, 7-15, and 31-33) except for the limitations regarding the equipment used." Therefore the rejection of claim 33 based limitations to gas mixtures as taught by Senzaki is unnecessary (Kobayashi teaches suitable gas mixtures) and improper.

Based on the preceding arguments, Appellants respectfully maintain that claim 33 is not unpatentable over Kobayashi in view of Senzaki and is in condition for allowance.

GROUND OF REJECTION 2

Claim 34 stands rejected under 35 U.S.C. §103(b) as being unpatentable over Kobayashi (EP 0 886 308 A2) in view of Senzaki (US 2006005106A1) and in further view of Park (US006962873B1).

In claim 34, Appellants claim "wherein said inert gas is helium and said reducing gas is hydrogen."

The Examiner stated "Park teaches using ammonia as the nitrogen species, or a mixture of nitrogen and hydrogen (column 7 lines 15-30). Thus substituting nitrogen and hydrogen for ammonia is an art recognized equivalent. Further, in a plasma, ammonia breaks down into nitrogen and hydrogen."

First, Appellants point out, and the Examiner has admitted that Park nitrides a cobalt layer. Appellants point out the Examiner has not provide any evidence that nitrogen and hydrogen are an art recognized equivalent for ammonia for nitriziding SiO_2 that nitrogen and hydrogen are an art recognized equivalent for ammonia for nitriziding SiO_2.

Second, the Examiner given no evidence to support the Examiners statement that "in a plasma, ammonia breaks down into nitrogen and hydrogen" and thus implying ammonia can supply the hydrogen gas of Applicants claim 34.

Based on the preceding arguments, Appellants respectfully maintain that claim 34 is not unpatentable over Kobayashi in view of Senzaki in further view of Park and is in condition for allowance.

GROUND OF REJECTION 3

Claims 35-38 under 35 U.S.C. §103(a) as being unpatentable over Kobayashi (EP 0 886 308 A2) in view of Senzaki (US 2006005106A1) and in further view of McFadden (US 6610615B1).

As per claim 35, the Examiners has stated that "Kobayashi teaches that the gases may react singly or in combination (column 10, lines 36-39) suggesting that there is no resultant product change dependent upon whether the gasses are placed in the chamber through single inlet or multiple inlets. Without evidence to the contrary, this limitation is an apparatus limitation rather than one on the actual process of making a film."

First Appellants point to Appellants FIGs. 8 and 9 and paragraphs 34 and 39, discussed *supra*, in conjunction with claim 14 and 15 as being evidence to the contrary.

Second Appellants point out that the three steps recited in claim 35, namely "generating", "transferring" and "introducing" are definitely method steps and that the so-called "apparatus limitations" perform the function of separating the method steps both logically in time (the apparatus limitations in concordance with the method step allow for only one sequence in which the three method steps may be performed) as well as in location.

Third, a person of ordinary skill in the art would know that an ionized or free radical species will react differently than a neutral species and that introducing the reducing gas through a separate port and not subjecting it to excitation in the remote plasma source precludes any possibility of exciting the reducing gas and is thus a method limitation.

Fourth, Appellants point out Appellants are claiming "transferring the nitridation species...through said first inlet port" and "introducing a neutral gas... through said second inlet port." which is not possible in either Kobayashi or Senzaki or their combination as described by

the Examiner. (A) There is only one inlet port in Kobayashi or Senzaki. (B) Kobayashi teaches exciting both the inert and nitrogen containing gas before introduction into the chamber. In Kobayashi, all gases are introduced into chamber 101 of FIG. 10 as neutral gases an there is no way of introducing a plasma species into the chamber. (C) Senzaki teaches exciting both the inert and nitrogen containing gas before introduction into the chamber. In Senzaki FIG. 1. Ar and N_2 are introduced into plasmas into source 14 and Ar^+ and N [a free radical, normally denoted N*] exit the plasma source and are introduced into chamber 12 and there is no way of introducing a non-plasma species into the chamber.

Fifth, the Examiner has misinterpreted Kobayashi col. 10, lines 36-39. It is illogical to interpret Kobayashi as "suggesting there is no resultant product change dependent upon whether the gases are placed into the chamber through a single or multiple inlets" as applied to Appellants invention since Kobayashi has only a single inlet and teaches only neutral species entering through the single inlet. Kobayashi does not contemplate multiple inlets and his teaching must be limited to single inlet systems. Appellants point out they claim neutral species that are introduced into the process chamber through a first port and plasma species are generated in a separate chamber and introduced into the plasma chamber through a second port which is far different from the teaching of Kobayashi..

Based on the preceding arguments, Appellants respectfully maintain that claim 35 is not unpatentable over Kobayashi in view of Senzaki and in further view of McFadden and is in condition for allowance.

As to claims 36 and 37, Appellants maintain that the Examiner introduced Senzaki to modify the equipment limitations of Kobayashi and not in the positive steps of Kobayashi stating

"Kobayashi teaches all the positive steps of claims 1, 7-15, and 31-33) except for the limitations regarding the equipment used." Therefore the rejection of claims 36 and 37 based limitations to gas mixtures as taught by Senzaki is unnecessary (Kobayashi teaches suitable gas mixtures) and improper.

Based on the preceding arguments, Appellants respectfully maintain that claims 36 and 39 are not unpatentable over Kobayashi in view of Senzaki and are in condition for allowance.

As to claim 38, the Examiner states, "Kobayashi and Senzaki are silent as to how the plasma is formed. McFadden (column 32 lines 30-33) teaches a plasma made with radio frequency."

The Examiners statement is incorrect and has been discussed *supra*, but will be repeated here. Kobayashi teaches in col. 11 lines 22-26 that filament 104 is heated and a [DC] voltage applied to generate a nitrogen plasma through electron impact. Senzaki teaches in paragraph 22 the plasma generator may be an ASTRON plasma generator though does not describe how it works. Therefore, there is no reason to combine McFadden with Kobayashi and Senzaki to merely substitute one plasmas generation type for another. In fact, the Examiner has impermissibly used the Appellants' teaching to hunt through the prior art for the claimed elements and combine them as claimed in violation of *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed Cir. 1991) which states "the suggestion and reasonable expectation of success must be founded in the prior art, not in the Appellant's disclosure."; *In re Bond*, 910 F.2d 831, 15 USPQ2d 1566 (Fed Cir. 1990) and *In re Laskowski*, 871, 910 F.2d 115, 117, 10 USPQ2d 1397, 1398 (Fed. Cir. 1989).

Based on the preceding arguments, Appellants respectfully maintain that claim 38 is not

unpatentable over Kobayashi in view of Senzaki and is in condition for allowance.

GROUND OF REJECTION 4

Claim 6 stands rejected under 35 U.S.C. §103(a) as being unpatentable over Kobayashi (EP 0 886 308 A2) in view of McFadden (US 6610615B1).

As to claim 6, Appellants find no relevance in the Examiner reason to combine references , to wit "helium has a lower ionization energy." The Examiner fails to indicate why a lower ionization energy should be substituted for hydrogen. The abstract of McFadden actually states "A gas having a lower ionization energy than nitrogen, such as for example, helium, maybe used in combination with nitrogen to produce a lower power plasma resulting in a steeper concentration curve for nitrogen in the silicon oxide film." The teaching of McFadden is opposed to the teaching of Kobayashi. Kobayashi teaches in FIGS. 6 and FIG. 9, a nitridation profile where the nitrogen concentration has a first peak at the insulating surface and a second peak at the oxide silicon interface, while McFadden teaches in FIG 1, a nitridation profile where the nitrogen concentration continually decreases with increasing distance from the surface of insulator. The resultant profile of Kobayashi would be further destroyed by increasing the steepness of the slope of nitrogen concentration versus distance into the substrate curve.

Thus there is no motivation to modify Kobayashi in view of Senzaki with McFadden because the modification destroys the purpose of Kobayashi, which is given in Kobayashi col. 3, lines 47-54, to wit "In the thus formed insulating film, nitrogen are contained in a relatively high concentration near the surface of the film and the semiconductor substrate. Nitrogen atoms contained near the interface improve interface properties and enable formation of a high-quality insulating film having a low interface state density." Thus, *In re Gordon*, 733 F.2d 900, 902, 221 U.S.P.Q 1125, 1127 (Fed. Cir 1984) which states there is no reason to combine references if the combination destroys the purpose, functionality or operability of the reference, is applicable.

Based on the preceding arguments, Appellants respectfully maintain that claim 6 is not unpatentable over Kobayashi in view of McFadden and is in condition for allowance

SUMMARY

In summary, Appellant respectfully requests reversal of the March 28, 2006 Office Action rejection of claims 1,4, 6-15 and 31-38.

Respectfully submitted,
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Burnham et al. Docket No.: BUR920020109US1

Serial No.: 10/604,905 Art Unit: 2813

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Title: **METHOD FOR FABRICATING A NITRIDED SILICON-OXIDE GATE DIELECTRIC**

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APPENDIX A - CLAIMS ON APPEAL

1. A method of fabricating a gate dielectric layer, comprising:

forming a silicon dioxide layer on a top surface of a substrate;

placing said substrate in a first chamber having a inlet first port and a second inlet port;

generating a plasma in a second chamber, said plasma comprising at least one nitridation species, said second chamber adjacent to said first chamber, said second chamber connected to said first chamber by said inlet first port in said first chamber;

transferring said nitridation species of said plasma from said second chamber to said first chamber through said first inlet port; and

performing a plasma nitridation in said first chamber using said nitridation species in a reducing atmosphere to convert said silicon dioxide layer into a silicon oxynitride layer.

4. The method of claim 32, wherein said inert gas is helium and said reducing gas is hydrogen,

ammonia, a mixture of hydrogen and nitrogen, a mixture of ammonia and nitrogen or a mixture of hydrogen, ammonia and nitrogen.

6. A method of fabricating a gate dielectric layer, comprising:

providing a substrate;

forming a silicon dioxide layer on a top surface of said substrate;

performing a plasma nitridation in a reducing atmosphere to convert said silicon dioxide layer into a silicon oxynitride layer;

wherein the step of performing a plasma nitridation is performed using plasma comprising nitrogen, an inert gas and a reducing gas; and

wherein said inert gas is helium and said reducing gas is hydrogen.

7. The method of claim 1, wherein said substrate includes a bulk silicon or silicon on a insulator substrate and said forming a silicon dioxide layer is formed by a process selected from the group consisting of native oxide growth in air or oxygen, thermal oxidation, rapid thermal oxidation, chemical vapor deposition and oxidizing cleaning processes.

8. The method of claim 1, wherein said silicon dioxide layer has a thickness of about 8 to 23 Å.

9. The method of claim 1, wherein said silicon oxynitride has a thickness of about 8 to 24 Å.

10. The method of claim 1, wherein said silicon oxynitride film contains between about 2 and 20 percent nitrogen.

11. The method of claim 1, wherein the concentration of nitrogen in said silicon oxynitride layer is between about 1E21 and 1E22 atm/cm^3.

12. The method of claim 1, wherein the step of performing a plasma nitridation imparts a dose of nitrogen in between about 1E14 and 5E14 atm/cm^2 to said silicon dioxide layer.

13. The method of claim 1, wherein said silicon oxynitride layer has a thickness of about 0 to 35% greater than the thickness of said silicon dioxide layer.

14. The method of claim 1, wherein the mean thickness of said silicon oxynitride layer varies by no more than about one-half angstrom sigma from a center to an edge of said substrate.

15. The method of claim 1, wherein the nitrogen concentration of said silicon oxynitride layer varies by not more than about 25% from a center to an edge of said substrate.

31. The method of claim 1, further including:

exhausting said second chamber through said first chamber.

32. The method of claim 1, further including:

generating a nitrogen, inert gas and reducing gas plasma in said second chamber from nitrogen, an inert gas and a reducing gas; and

transferring said nitrogen, inert gas and reducing gas plasma from said second chamber

into said first chamber through said first inlet port of said first chamber.

33. The method of claim 32, wherein said inert gas is helium and said reducing gas is deuterium, deuterated ammonia, a mixture of deuterium and nitrogen, a mixture of deuterated ammonia and nitrogen, a mixture of deuterium, deuterated ammonia and nitrogen, or a mixture of deuterium, ammonia and nitrogen.

34. The method of claim 32, wherein said inert gas is helium and said reducing gas is hydrogen.

35. The method of claim 1, further including:

generating a nitrogen and inert gas plasma in said second chamber from nitrogen and an inert gas;

transferring said nitrogen, inert gas and reducing gas plasma from said second chamber into said first chamber through said first inlet port of said first chamber; and

introducing a neutral reducing gas into said first chamber through said second inlet port of said first chamber.

36. The method of claim 35, wherein said inert gas is helium and said reducing gas is hydrogen, ammonia, a mixture of hydrogen and nitrogen, a mixture of ammonia and nitrogen or a mixture of hydrogen, ammonia and nitrogen

37. The method of claim 35, wherein said inert gas is helium and said reducing gas is deuterium, deuterated ammonia, a mixture of deuterium and nitrogen, a mixture of deuterated ammonia and

nitrogen, a mixture of deuterium, deuterated ammonia and nitrogen, or a mixture of deuterium, ammonia and nitrogen.

38. The method of claim 1, wherein said nitridation plasma is generated by radio frequency excitation.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Burnham et al. Docket No.: BUR920020109US1

Serial No.: 10/604,905 Art Unit: 2813

Filed: August 26, 2003 Examiner: David S. Blum

Title: **METHOD FOR FABRICATING A NITRIDED SILICON-OXIDE GATE DIELECTRIC**

Honorable Commissioner for Patents
P. O. Box 1450
Alexandria, VA 22313-1450

APPENDIX B - EVIDENCE

There is no evidence entered by the Examiner and relied upon by Appellant in this appeal.

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APPENDIX C - RELATED PROCEEDINGS

There are no proceedings identified in the "Related Appeals and Interferences" section.